# DESCRIPTION

## COMPONENT MOUNTING APPARATUS AND COMPONENT MOUNTING METHOD

### Technical Field

The present invention relates to a component mounting apparatus and method for holding and picking up a plurality of components fed from a component feed unit by a head unit and mounting each of the held components on a board and relates, in particular, to a component mounting apparatus and component mounting method for executing the component mounting by controlling the operation of feeding the components of the component feed unit and the holding and picking up operation of the head unit while correlating them with each other.

### Background Art

Conventionally, as the component mounting apparatus and component mounting method of this kind, various ones have been known. As one example of the various component mounting apparatuses of the kind, Fig. 18 shows a schematic explanatory view showing the schematic construction of a conventional component mounting apparatus 500 (refer to, for example, Japanese examined Patent Publication No.2940193).

As shown in Fig. 18, the reference numeral 501 denotes a rotary head as one example of the head unit, and a plurality of transfer heads 502 are provided along the circumferential direction of this rotary head 501. Further, each of the transfer heads 502 is provided with a nozzle 503 that is able to releasably suck by vacuum and hold a component P such as an electronic component. The rotary head 501 is also provided with a motor M1 as a driving motor and is able to rotate by being driven by the motor M1. Each nozzle 503 is elevatable in accordance with the drive by the motor M1 of the rotary head 501.

Moreover, as shown in Fig. 18, the component mounting apparatus 500 is provided with an X-Y table 504 that releasably holds a board 514 on its machine table (not shown) and moves the board 514 in the held state in the illustrated X-axis direction or the Y-axis direction, thereby allowing the board to be aligned in a position with the component P held by each nozzle 503 of the rotary head 501. Moreover, the X-Y table 504 is provided with an X-motor MX capable of performing the conveyance operation in the illustrated X-axis direction by the driving of the motor and a Y-motor MY capable of performing the conveyance operation in the illustrated Y-axis direction by the driving of the motor.

Moreover, as shown in Fig. 18, the component

mounting apparatus 500 is provided with a component feed unit 505 that feeds a plurality of components P to be mounted on the board 514 while allowing the components to be picked up by the respective nozzles 503. This component feed unit 505 is also provided with a plurality of parts feeders 508 (only one parts feeder 508 is shown in Fig. 18) such as tape feeders that supply (i.e., feed) the plurality of components P received on a carrier tape while allowing the components to be picked up and a slide base 506 that moves a table 507 on which the parts feeders 508 are placed together with the parts feeders 508 along the illustrated Y-axis direction. Further, the slide base 506 is provided with a ball screw shaft section 509 arranged in the illustrated Y-axis direction, a nut section (not shown) that is meshed with this ball screw shaft section 509 and fixed to the lower surface of the table 507 and a motor M2 that rotatively drives the ball screw shaft section 509 around its axial center. With this arrangement, the table 507 can be moved so as to advance and retreat along the illustrated Y-axis direction by rotatively driving the ball screw shaft section 509 by the motor M2 on the slide base 506, and the component P of the desired parts feeder 508 can be stopped in the pickup position of the nozzle 503.

Moreover, the component mounting apparatus 500 is provided with a vacuum unit 510, and the vacuum unit 510

communicates with each of the nozzles 503 through a tube 511. Moreover, a solenoid valve 512 is provided partway on the tube 511, and by turning on and off this solenoid valve 512, the component P can be held by vacuum suction and released from the held state at the tip of the nozzle 503.

Moreover, the component mounting apparatus 500 is further provided with a control unit 513 that executes the centralized control of the motor M1 for the motion control of the rotary head 501, the control of the vacuum unit 510 and the solenoid valve 512, the control of the motors MX and MY for the motion control of the X-Y table 504 and the control of the motor M2 for the motion the control of the component feed unit 505 while correlating them one another. The operations of the constituent sections of the component mounting apparatus 500 are controlled by the control unit 513, executing the component mounting operation of making the rotary head 501 suck by vacuum, hold and pick up a component P from the parts feeder 508 by means of the nozzle 503 while rotating, then relatively transferring this component P onto the board 514, releasing the hold by releasing the vacuum suction state and mounting the component P onto the board 514. As in the control unit 513 of the component mounting apparatus 500, the control system for intensively executing the control of the operations of a plurality of constituent sections by one control unit is

generally called the "centralized control system".

In recent years, the motion control in each constituent section of a component mounting apparatus has been advanced and complicated in accordance with the diversification of component mounting and the improvement in accuracy of component mounting, and the control unit 513 is required to be able to execute advanced complicated control also in the component mounting apparatus 500 that adopts the aforementioned centralized control system.

However, in accordance with the advancement and the complication of control in component mounting, despite the fact that it is most efficient to confirm the fundamental operations, operational performances and so on of the individual constituent sections at an early stage and thereafter confirm the control performance of the entire component mounting apparatus in the apparatus development process, the centralized control system is adopted as described above. Therefore, it is difficult to separate the control software and so on for each of the individual constituent sections in the control unit 513, and this disadvantageously becomes a factor for hindering the shortening of the development period. As described above, unless the development period can be shortened, it becomes impossible to provide apparatuses that can cope with a variety of needs demanded by the users of the

component mounting apparatuses in a short period.

Moreover, there is no small number of cases where the constituent sections of the component mounting apparatus 500 are concurrently controlled in parallel with one another. In such a case, the control throughput of the control unit 513 increases in accordance with the advancement and the complication of control as described above, possibly failing in improving the processing speed and sometimes causing a reduction in the control speed and a variation in the control speed. This disadvantageously becomes a factor for hindering the improvement of controllability during the component mounting.

Disclosure of Invention

Accordingly, the object of the present invention is to solve the aforementioned problems and provide a component mounting apparatus and component mounting method provided with a control system that is able to improve the controllability of the motion control of the constituent sections of the head unit, the component feed unit and so on during the component mounting of holding and picking up a plurality of components fed from a component feed unit by means of the head unit and mounting each of the held components onto a board and to reduce the development period of the control of the component mounting.

In accomplishing these and other aspects, according to a first aspect of the present invention, there is provided a component mounting apparatus comprising:

a component feed unit for executing component feed operation for feeding a plurality of components in order to allow the components to be picked up;

a head unit which has a plurality of component holding members for releasably holding the components, for executing component holding and pickup operation for holding and picking up the components from the component feed unit to mount the components onto a board by one or the plurality of component holding members;

a head unit control section for controlling the component holding and pickup operation of the head unit;

a component feed unit control section for controlling the component feed operation of the component feed unit; and

a main control section for transmitting recipes of an operation programs for executing the operations in the head unit control section and the component feed unit control section to the head unit control section and the component feed unit control section,

wherein the head unit control section is operable to execute the component holding and pickup operation on basis of the transmitted recipe, and the component feed

unit control section is operable to execute the component feed operation based on the transmitted recipe.

According to a second aspect of the present invention, there is provided the component mounting apparatus as defined in the first aspect, wherein

the head unit control section is provided for the head unit, and the component feed unit control section is provided for the component feed unit.

According to a third aspect of the present invention, there is provided the component mounting apparatus as defined in the first aspect, wherein

the head unit control section is operable to execute the component holding and pickup operation on basis of the transmitted recipe and is operable to transmit a timing signal based on the execution to the component feed unit control section, and

the component feed unit control section completes the component feed operation on basis of the transmitted recipe and timing signal.

According to a fourth aspect of the present invention, there is provided the component mounting apparatus as defined in the third aspect, wherein

the component feed unit control section is operable to transmit a timing signal based on the executed component feed operation to the head unit control section,

and

the head unit control section is operable to complete the component holding and pickup operation on basis of the transmitted timing signal and recipe.

According to a fifth aspect of the present invention, there is provided the component mounting apparatus as defined in the first aspect, further comprising:

a head moving unit for executing head moving operation for moving the head unit in a direction roughly parallel to a surface of the board; and

a moving unit control section for controlling the head moving operation of the head moving unit,

wherein the main control section is operable to transmit the recipe for executing the head moving operation in the moving unit control section to the moving unit control section, and

the moving unit control section is operable to execute the head moving operation on basis of the transmitted recipe.

According to a sixth aspect of the present invention, there is provided the component mounting apparatus as defined in the fifth aspect, wherein the moving unit control section is provided for the head moving unit.

According to a seventh aspect of the present invention, there is provided the component mounting apparatus as defined in the fifth aspect, wherein

the head unit control section is operable to transmit a timing signal based on the execution of the operation to the moving unit control section, and

the moving unit control section is operable to complete the head moving operation on basis of the transmitted recipe and timing signal.

According to an eight aspect of the present invention, there is provided the component mounting apparatus as defined in the seventh aspect, wherein

the moving unit control section is operable to transmit a timing signal based on the executed head moving operation to the head unit control section, and

the head unit control section is operable to complete the component holding and pickup operation on basis of the transmitted timing signal and recipe.

According to a ninth aspect of the present invention, there is provided the component mounting apparatus as defined in the fifth aspect, wherein

the head unit is operable to execute component mounting operation for mounting the component or components held by the one or the plurality of component holding members by releasing the holding on the board,

the main control section is operable to transmit the recipe for executing the component mounting operation to the head unit control section and is operable to transmit the recipe for executing the head moving operation for the component mounting operation to the moving unit control section,

the head unit control section is operable to execute the component mounting operation on basis of the transmitted recipe, and the moving unit control section is operable to execute the head moving operation for the component mounting operation on basis of the transmitted recipe.

According to a 10th aspect of the present invention, there is provided the component mounting apparatus as defined in the ninth aspect, wherein

the head unit control section is operable to execute the component mounting operation on basis of the transmitted recipe and is operable to transmit a timing signal based on the execution of the operation to the moving unit control section, and

the moving unit control section is operable to complete the head moving operation for the component mounting operation on basis of the transmitted recipe and timing signal.

According to an 11th aspect of the present

invention, there is provided the component mounting apparatus as defined in third aspect, wherein

the recipe for executing for the component holding and pickup operation comprises:

an operation program for executing component holding preparation operation for moving down the one or the plurality of component holding members for holding the component or components in the head unit to a component holding standby height position along a direction roughly perpendicular to a surface of the board; and

an operation program for executing component holding main operation for further moving down the one or the plurality of component holding members from the component holding standby height position and holding the component or components allowing to be picked up in the component feed unit by the one or the plurality of component holding members, and

the head unit control section is operable to make the component feed unit control section recognize completion of the component holding preparation operation on basis of the recipe by transmitting the timing signal.

According to a 12th aspect of the present invention, there is provided the component mounting apparatus as defined in the 11th aspect, wherein

the component feed unit comprises a plurality of

component pickup positions in which the components are arranged allowing to be picked up by the component holding member,

the recipe for executing the component feed operation comprises:

an operation program for executing component feed preparation operation for transporting the components in the component feed unit so that the components are positioned in the component pickup positions; and

an operation program for executing component feed main operation for putting the transported components into a state in which the components can be picked up by the component holding member, and

the component feed unit control section is operable to execute the component feed preparation operation on basis of the recipe, to complete the component feed main operation on basis of the recipe and the timing signal from the head unit control section and to make the head unit control section recognize completion of the component feed main operation by transmitting the timing signal to the head unit control section.

According to a 13th aspect of the present invention, there is provided the component mounting apparatus as defined in the third aspect or seventh aspect, wherein the head unit control section is operable to

transmit a plurality of timing signals formed on basis of elevation positions of each of the component holding members along a direction roughly perpendicular to the surface of the board.

According to a 14th aspect of the present invention, there is provided the component mounting apparatus as defined in the fifth aspect, wherein

the main control section comprises:

a recipe forming section for forming each of the recipes; and

a recipe transmission section for transmitting each of the formed recipes.

According to a 15th aspect of the present invention, there is provided the component mounting apparatus as defined in the 14th aspect, wherein

the head unit control section, the component feed unit control section or the moving unit control section is operable to transmit error information generated when the operations are executed on the basis of the respective recipes to the main control section,

in the main control section,

the recipe forming section is operable to correct the recipe relevant to the error information out of the already transmitted recipes on basis of the transmitted error information, and

the recipe transmission section is operable to transmit the corrected recipe while in order to allow the already transmitted recipe to be replaced by the corrected recipe.

According to a 16th aspect of the present invention, there is provided the component mounting apparatus as defined in the third aspect, wherein

the component feed unit comprises a plurality of component pickup positions that are arranged in a line with a constant pitch and arranges the components allowing to be picked up by the component holding members,

the component holding members are arranged with a constant pitch of an integral multiple of the constant pitch in the head unit along the direction in which the component pickup positions are arranged, and

the recipe for the component feed operation transmitted from the main control section to the component feed unit control section comprises at least positional information of the one or the plurality of component pickup positions where the component feed operation is executed.

According to a 17th aspect of the present invention, there is provided the component mounting apparatus as defined in the 16th aspect, wherein

the recipe for the component holding and pickup operation transmitted from the main control section to the

head unit control section comprises at least information capable of recognizing the one or the plurality of component holding members in which the component holding and pickup operation is executed and positional information of the one or the plurality of component pickup positions where the component feed operation is executed.

According to an 18th aspect of the present invention, there is provided the component mounting apparatus as defined in the fifth aspect, wherein

the recipe for the head moving operation transmitted from the main control section to the moving unit control section comprises at least positional information of a movement position of the one or the plurality of component holding members in a direction roughly along the surface of the board where the component holding and pickup operation is executed or the component mounting operation is executed.

According to a 19th aspect of the present invention, there is provided the component mounting apparatus as defined in the 18th aspect, wherein

the recipe for the component mounting operation transmitted from the main control section to the head unit control section comprises at least information capable of recognizing the one or the plurality of component holding members by which the component holding and pickup operation

is executed or the component mounting operation is executed.

According to a 20th aspect of the present invention, there is provided a component mounting apparatus comprising:

a component feed unit for executing component feed operation for feeding a plurality of components in order to allow the components to be picked up;

a head unit which has a plurality of component holding members for releasably holding the components, for executing component holding and pickup operation for holding and picking up the components from the component feed unit to mount the components onto a board by one or the plurality of component holding members;

a head unit control section for controlling the component holding and pickup operation of the head unit; and

a main control section for transmitting recipes of operation programs for executing the component holding and pickup operation in the head unit control section to the head unit control section and for controlling the component feed operation in the component feed unit,

wherein the main control section is operable to complete the component feed operation and is operable to transmit the recipe to the head unit control section, and

the head unit control section is operable to

complete the component holding and pickup operation on basis of the transmitted recipe.

According to a 21st aspect of the present invention, there is provided the component mounting apparatus as defined in the 20th aspect, wherein the head unit control section is provided for the head unit.

According to a 22nd aspect of the present invention, there is provided a component mounting method for executing component feed operation for feeding a plurality of components in a component feed unit in order to allow the components to be picked up and executing component holding and pickup operation for picking up the components from the component feed unit to mount the components onto a board in a head unit that has a plurality of component holding members that releasably hold the components by the one or the plurality of component holding members, the method comprising:

receiving a recipe for the component holding and pickup operation of an operation program for executing the component holding and pickup operation in the head unit, executing the component holding and pickup operation on basis of the received recipe and transmitting a timing signal based on the execution of the operation to the component feed unit; and

receiving a recipe for the component feed

operation of an operation program for executing the component feed operation in the component feed unit and completing the component feed operation on basis of the received recipe and the timing signal transmitted from the head unit.

According to a 23rd aspect of the present invention, there is provided the component mounting method as defined in the 22nd aspect, wherein

each of the recipe for the component holding and pickup operation and the recipe for the component feed operation is formed on a component mounting apparatus main body side provided with the head unit and the component feed unit, and

each of the formed recipes is transmitted from the component mounting apparatus main body side to the head unit and the component feed unit.

According to a 24th aspect of the preset invention, there is provided the component mounting method as defined in the 22nd aspect, wherein

the timing signal on basis of the execution of the component feed operation based on the recipe is transmitted to the head unit during the execution in the component feed unit, and

the component holding and pickup operation is executed in the head unit also on basis of the timing

signal transmitted from the component feed unit.

According to a 25th aspect of the present invention, there is provided the component mounting method as defined in the 22nd, further comprising:

executing head moving operation for moving the head unit to a place above the board in a head moving unit that moves the head unit in a direction roughly parallel to a surface of the board; and

executing component mounting operation for mounting the component or components held by the one or the plurality of component holding members onto the board,

whereby a recipe for the component mounting operation for executing the component mounting operation is received in the head unit, the component mounting operation is executed on the basis of the received recipe and a timing signal based on the execution is transmitted to the head moving unit; and

a recipe for the head moving operation for executing the head moving operation is received in the head moving unit, and the head moving operation is completed on basis of the received recipe and the timing signal transmitted from the head unit.

According to a 26th aspect of the present invention, there is provided the component mounting method as defined in the 25th, wherein

each of the recipe for the component mounting operation and the recipe for the head moving operation is formed on the component mounting apparatus main body side, and

each of the formed recipes is transmitted from the component mounting apparatus main body side to the head unit and the head moving unit.

According to a 27th aspect of the present invention, there is provided the component mounting method as defined in the 25th aspect, wherein

the timing signal on basis of the execution of the head moving operation based on the recipe is transmitted to the head unit during the execution in the head moving unit, and

the component mounting operation is executed in the head unit also on the basis of the timing signal transmitted from the head moving unit.

According to the first through the third aspects of the present invention, instead of adopting the "centralized control system" that intensively executes the operation control of a plurality of constituent sections by one control unit as in the control system of the conventional component mounting apparatus, each of the constituent sections is individually provided with a control section, and each operation control is enabled by

transmitting and receiving the timing signal between the control sections while being correlated with one another. With this arrangement, the fundamental operations, the operational controllability and so on of the constituent sections can be confirmed at an early stage in the development process, and the confirmation of the control performance of the entire component mounting apparatus can be efficiently achieved.

In concrete, there are provided the control sections of the head unit control section that is provided for the head unit and is able to control the component holding and pickup operation by the head unit, the component feed unit control section that is provided for the component feed unit and is able to control the component feed operation by the component feed unit and the main control section that is able to transmit the recipes of the operation program capable of executing the operations to the head unit control section and the component feed unit control section. By executing the operations in the head unit control section and the component feed unit control section on the basis of the recipes transmitted from the main control section and the transmitting the timing signal based on the execution from the head unit control section to the component feed unit control section, the operations can be executed while being

correlated with one another.

Therefore, the functions, the control software and so on provided for the main control section can be reduced, and the functions and the control software borne by the conventional control unit can be distributionally provided for the head unit control section and the component feed unit control section in place of them. Therefore, if the recipes and the timing signals, which can be pseudo-formable even without actual constituent sections, are prepared (that is the recipes and the timing signals are prepared hypothetically) in the apparatus development stage, the functions and the control performances can be confirmed at an early stage in distribution units of the head unit control section, the component feed unit control section and so on, and the development period can be markedly shortened in comparison with the conventional centralized control system.

Moreover, by shortening the development period of the component mounting apparatus as described above, it becomes possible to provide an apparatus that answers the various needs of the users of the component mounting apparatus in a short time taking advantage of the shortened period. Moreover, it is possible to obtain a period for sufficiently proving the controllability and therefore provide a component mounting apparatus whose control

accuracy is improved.

Moreover, by making the distribution units of the head unit control section, the component feed unit control section and so on distributionally bear the advanced complicated control required for the current component mounting apparatus without concentrating the control processing on one portion, the processing speed can be improved, and the controllability can be made satisfactory.

Furthermore, the mutual correlation between the component holding and pickup operation by the head unit and the component feed operation by the component feed unit can be achieved by directly executing the transmission and reception of the timing signal between the head unit control section and the component feed unit control section without the intervention of the main control section. Accordingly, there can be provided a component mounting apparatus that can improve the control response by the direct communications.

Moreover, the information communications between the head unit control section and the component feed unit control section can be suppressed principally to the mere transmission and reception of the timing signal, and this therefore allows the amount of communications between them to be minimized, making it possible to suppress the occurrence of control delay.

Moreover, the operations are executed between the head unit control section and the component feed unit control section on the basis of the received recipe. By this operation, wiring between the main control section and the head unit control section and between the main control section and the component feed unit control section can be reduced, and this allows the apparatus manufacturing cost of the component mounting apparatus to be reduced also in terms of hardware.

Moreover, even if the head unit control section and the component feed unit control section are provided in places other than the places of the head unit and the component feed unit, the aforementioned effects can be obtained.

Furthermore, in the case where operations of a distant mutual correlation are executed in the head unit and the component feed unit, the aforementioned effects can be obtained by executing control individually based on the recipes without transferring the timing signal between the head unit control section and the component feed unit control section.

According to the fourth aspect of the present invention, the component feed unit control section is able to transmit the timing signal based on the executed component feed operation to the head unit control section.

With this arrangement, the component holding and pickup operation can be executed in the head unit control section on the basis of the timing signal, and the head unit control section and the component feed unit control section can be correlated with each other with regard to the interactive control, allowing the controllability to be further improved.

According to the fifth through the tenth aspects of the present invention, the moving unit control section that controls the movement operation of the head unit is further provided. With this arrangement, the head unit control section and the moving unit control section can be correlated with regard to control similarly to the aforementioned relation between the head unit control section and the component feed unit control section, and effects similar to the effects of the aforementioned aspects can be obtained.

Moreover, even if the moving unit control section is provided in a place other than the place of the head moving unit, the aforementioned effects can be obtained.

Furthermore, in the case where operations of a distant mutual correlation are executed in the head unit and the head moving unit, the aforementioned effects can be obtained by executing control individually based on the recipes without transferring the timing signal between the

head unit control section and the moving unit control section.

According to the eleventh aspect of the present invention, the component holding and pickup operation includes the component holding preparation operation and the component holding main operation. By making the component feed unit control section recognize the completion of the component holding preparation operation on the basis of the recipe by the transmission of the timing signal, the head unit control section can recognize the timing of putting the component to be held and picked up in the component feed unit control section into the state in which it can be picked up, and the respective operations can be correlated with each other. By virtue of the thus enabled correlation, the effects of the aforementioned aspects can be concretely obtained.

According to the twelfth aspect of the present invention, the component feed operation includes the component feed preparation operation and the component feed main operation. The component feed unit control section is able to execute the component feed preparation operation on the basis of the recipe, complete the component feed main operation on the basis of the recipe and the timing signal from the head unit control section and make the head unit control section recognize the completion of the component

feed main operation by the transmission of the timing signal to the head unit control section, and the mutual operation control can be more closely correlated. By virtue of the thus enabled correlation, the effects of the aforementioned aspects can be concretely obtained.

According to the thirteenth aspect of the present invention, the head unit control section is able to transmit the plurality of timing signals on the basis of the elevation position of each component holding member. With this arrangement, the component holding and pickup operation executed by the elevation of the component holding member and the component feed operation can be closely correlated with each other, and the effects of the aforementioned aspects can be obtained.

According to the fourteenth aspect of the present invention, the main control section is provided with the recipe forming section and the recipe transmission section. With this arrangement, it becomes possible to input NC data and so on of the mounting data for component mounting to the main control section, form each recipe on the basis of the NC data and so on by the recipe forming section in the main control section and transmit each formed recipe from the recipe transmission section to the control sections, so that the aforementioned effects can concretely be achieved.

According to the fifteenth aspect of the present

invention, when an operation error occurs in any one of the head unit control section, the component feed unit control section and the moving unit control section, the error information is transmitted to the main control section, and the recipe forming section can correct the recipes on the basis of the transmitted error information in the main control section. Therefore, it becomes possible to cope with various operation errors that possibility occur during the component mounting while correlating them with each other with the effects of the aforementioned aspects allowed to be obtained.

According to the sixteenth aspect through the nineteenth aspect of the present invention, the recipes to be executed in the control sections of the head unit control section, the component feed unit control section and the moving unit control section include at least the position information of the sections. With this arrangement, the operations can be reliably executed on the basis of the recipes in the respective control sections, and the effects of the aforementioned aspects can be achieved.

According to the twentieth aspect or the twenty-first aspect of the present invention, even when the main control section capable of executing the operation control of the component feed unit and the head unit control

section capable of executing the control of the operation of the head unit are provided, effects substantially similar to the effects of the first aspect through the third aspect can be obtained.

According to the twenty-second aspect of the present invention, instead of adopting the "centralized control system" that intensively executes the operation control of a plurality of constituent sections in one portion as in the control system of the conventional component mounting apparatus, each of the constituent sections is provided with a function capable of individually executing control, and each operation control is enabled by transmitting and receiving the timing signal between the constituent sections while being correlated with one another. With this arrangement, there can be provided a component mounting method capable of confirming the fundamental operations, operational controllability and so on of the constituent sections at an early stage in the development process and allowing the control performance of the entire component mounting apparatus to be efficiently performed. Accordingly, there can be provided a component mounting method capable of obtaining effects similar to the effects of the third aspect and obtaining the effects of shortening the apparatus development period and improving the controllability such as the improvement of control

response.

According to the twenty-third aspect through the twenty-seventh aspect of the present invention, the operations of the component holding and pickup operation, the component feed operation, the component mounting operation and the head moving operation can be executed on the basis of the recipes received in the constituent sections of the head unit, the component feed unit and the head moving unit. In addition, by transmitting and receiving the timing signal based on the execution of the operations between the constituent sections and executing the operations also on the basis of the received timing signal, the control operations of the constituent sections can be closely correlated with one another. Accordingly, there can be provided a component mounting method capable of concretely obtaining the effects of the twenty-second aspect during the component mounting.

Brief Description of Drawings

These and other aspects and features of the present invention will become clear from the following description taken in conjunction with the preferred embodiments thereof with reference to the accompanying drawings, in which:

Fig. 1 is a schematic perspective view of a

component mounting apparatus according to a first embodiment of the present invention;

Fig. 2 is a partially transparent schematic plan view showing an arrangement relation between a head unit and a component feed unit in the component mounting apparatus of the first embodiment;

Fig. 3 is a control block diagram of a distributed control system provided for the component mounting apparatus of the first embodiment;

Fig. 4 is a flow chart of the operation of component mounting executed in the component mounting apparatus of the first embodiment;

Fig. 5 is a schematic control flow chart of a component holding and pickup process;

Fig. 6 is a control flow chart continued from Fig. 5;

Fig. 7 is a flow chart showing the procedure of the control operation of the component holding and pickup process of Fig. 5;

Fig. 8 is a timing chart showing a state in which a height position is changed by the elevation of a suction nozzle in the component holding and pickup process of Fig. 5;

Fig. 9 is a control block diagram according to a modification example of a component feed distribution unit

in the control block diagram of the distributed control system of Fig. 3;

Fig. 10 is a control flow chart showing the case where an error occurs in the component holding and pickup process;

Fig. 11 is a schematic control flow chart of a component mounting process;

Fig. 12 is a flow chart showing the procedure of the control operation of the component mounting process of Fig. 11;

Fig. 13 is a timing chart showing a relation between a head unit moving operation by an X-Y robot and a suction nozzle elevating operation in the component mounting process of Fig. 11;

Fig. 14 is a schematic control flow chart in the case where a component feed tray is subjected to the component holding and pickup process of Fig. 5;

Fig. 15 is a control block diagram of a distributed control system provided for a component mounting apparatus according to a second embodiment of the present invention;

Fig. 16 is a schematic perspective view showing the schematic construction of a component mounting apparatus according to a third embodiment of the present invention;

Fig. 17 is a control block diagram of a distributed control system provided for the component mounting apparatus of the third embodiment; and

Fig. 18 is a schematic explanatory view showing the construction of the control of a conventional component mounting apparatus.

## Best Mode for Carrying Out the Invention

Before describing the embodiments of the present invention, the definitions of the "terms" used in the present specification and claims are explained first.

The term of "recipe" means an operation program, which is the operation program executed in automatically executing, for example, the operation executed in the component mounting apparatus or by the component mounting method.

The term of "timing signal" means a signal outputted (or transmitted) in accordance with the contents of the operation in executing the aforementioned recipe and means a message signal intended for transmitting the contents of execution or the state of execution of the self operation to the destination of output. It is to be noted that this timing signal is called the "event" ("event signal") in each of the embodiments of the present invention described below.

The term of "component" means components including electronic components, mechanical components, optical components and so on. The electronic components include, for example, chip components (resistors, capacitors, etc.), IC components (bare IC chips, IC-integrated components, etc.) and electronic circuit connecting type components (connector components, etc.). Moreover, such components are principally received on a carrier tape and might be fed by a component feed cassette or the like or fed in a state in which the components are arranged and received on a component feed tray.

The term of "board" means a circuit forming body in or on which an electronic circuit, a photoelectric circuit or the like is formed and means an object with a circuit formed, such as a circuit board of a resin board, a paper phenol board, a ceramic board, a glass epoxy board, a film board or the like, a circuit board of a single-layer board, a multi-layer board or the like, a component, a casing, a frame or the like.

Before the description of the present invention proceeds, it is to be noted that like components are denoted by like reference numerals throughout the accompanying drawings.

The embodiments according to the present invention will be described in detail below with reference

to the drawings.

(First Embodiment)

Fig. 1 shows a schematic explanatory view schematically showing the construction of a component mounting apparatus 100 as one example of the component mounting apparatus according to the first embodiment of the present invention.

(Overall Construction of the Component Mounting Apparatus)

As shown in Fig. 1, the component mounting apparatus 100 is provided with a component feed unit 6 as one example of a component feed unit for feeding a plurality of components 1 while allowing the components 1 to be picked up, a stage 5 as one example of a board holding section for releasably holding a board 2 on which each of the components 1 to be fed is mounted, a head unit 4 that holds and picks up each of the components 1 fed from the component feed unit 6 while allowing each of the components to be picked up and executes the mounting of each of the held components onto the board 2 held by the stage 5, and an X-Y robot 8 as one example of a head moving unit for executing the conveyance operation of this head unit 4 in a direction roughly along the surface of the board 2.

Moreover, as shown in Fig. 1, a plurality of, for

example, ten suction nozzles 3 as one example of a component holding member that releasably holds the component 1 on the upper surface thereof are provided on the lower surface of the head unit 4. Moreover, the suction nozzles 3 can individually perform suction or release of suction and holding of the component 1, and the suction nozzles 3 can be individually moved up and down along the direction roughly perpendicular to the surface of the board 2.

Moreover, as shown in Fig. 1, the X-Y robot 8 is provided with an X-axis robot 8a that supports the head unit 4 and makes the head unit 4 advance and retreat in the illustrated X-axis direction and a Y-axis robot 8b that supports the X-axis robot 8a and makes the X-axis robot 8a advance and retreat in the illustrated Y-axis direction. With this arrangement, the head unit 4, i.e., the suction nozzles 3 provided for the head unit 4 can be moved in the illustrated X-axis direction or Y-axis direction. It is to be noted that the illustrated X-axis direction and Y-axis direction are directions that are roughly parallel to the surface of the board 2 and perpendicular to each other.

Moreover, the component feed unit 6 is provided with a plurality of component feed cassettes 7, which are provided with so-called taping components such that a plurality of components 1 are received on a carrier tape

while being allowed to be picked up and the received components 1 are put in a state in which they can be picked up by feeding the provided taping components, adjacently to each other along the illustrated X-axis direction. Moreover, the component feed cassettes 7 are provided arranged so that component pickup positions 7a, where the components 1 are positioned in a state in which they can be picked up, are arranged in a line along the X-axis direction.

Moreover, the stage 5 is arranged on a machine table 10 of the component mounting apparatus 100, and a board conveyance unit 9 that conveys and supplies a board 2 from the right-hand side in the illustrated X-axis direction to the stage 5 and conveys and ejects the board 2 from the stage 5 to the left-hand side in the illustrated X-axis direction.

Moreover, the component mounting apparatus 100 is provided with a control system for executing control of the operations of the head unit 4, the component feed unit 6, the X-Y robot 8, the board conveyance unit 9 and so on, which are the constituent sections provided for the component mounting apparatus 100 while correlating the sections one another. The construction of this control system will be described in detail later.

(Constructions of the Head Unit and Component Feed

Unit)

A mutual arrangement relation between each of the suction nozzles 3 of the head unit 4 provided for the component mounting apparatus 100 and each of the component feed cassettes 7 of the component feed unit 6 will be described with reference to the partially transparent schematic explanatory plan view shown in Fig. 2. In the schematic explanatory plan view shown in Fig. 2, six component feed cassettes 7 out of the plurality of component feed cassettes 7 provided for the component feed unit 6 are shown for the sake of easy understanding of the explanation. However, the number of the component feed cassettes 7 in the component feed unit 6 is not limited only to the above-mentioned number and is allowed to be freely determined according to the embodiment thereof.

As shown in Fig. 2, the head unit 4 is provided with ten suction nozzles 3, which are arranged in a matrix of five in the illustrated X-axis direction by two in the illustrated Y-axis direction, i.e., a matrix of five rows by two columns (or two rows by five columns). Moreover, the suction nozzles 3 are arranged with a constant pitch P1 in the illustrated X-axis direction. Concretely, in Fig. 2, the suction nozzles 3-1, 3-2, 3-3, 3-4 and 3-5 are arranged in order from the left-hand side to the right-hand side in the figure as a total of five suction nozzles 3 in the

lower column in the illustrated Y-axis direction. Moreover, the suction nozzles 3-6, 3-7, 3-8, 3-9 and 3-10 are arranged in order from the left-hand side to the right-hand side in the figure as a total of five suction nozzles 3 in the upper column in the illustrated Y-axis direction. When a specified one of the suction nozzles 3 provided for the head unit 4 is used in the description provided later, the suction nozzle 3 is specified as "the suction nozzle 3-N" (note that N is any one of the integers of 1 to 10). When a suction nozzle 3 is used without being specified, the suction nozzle 3 is simply referred to as "the suction nozzle 3".

On the other hand, in the component feed unit 6, six component feed cassettes 7 are arranged as one example of the plurality of component feed cassettes 7 with the taping component feed direction extended along the illustrated Y-axis direction, and the component pickup positions 7a provided for the cassettes are arranged with a constant pitch P2 along the illustrated X-axis direction. Concretely, in Fig. 2, the component feed cassettes 7-1, 7-2, 7-3, 7-4, 7-5, and 7-6 are arranged in order from the left-hand side to the right-hand side in the figure. When a specified one of the component feed cassettes 7 provided for the component feed unit 6 is used in the description provided later, the component feed cassette 7 is specified

as "the component feed cassette 7-N" (note that N is any one of the integers of 1 to 6). When a component feed cassette 7 is used without being specified, the component feed cassette 7 is simply referred to as "the component feed cassette 7".

Moreover, the pitch P1 of the suction nozzles 3 has a dimension of an integral multiple of the pitch P2 of the component feed cassettes 7 (or the component pickup positions 7a). In the present first embodiment, for example, the pitch P1 and the pitch P2 have same dimension. Due to the relation possessed by the head unit 4 and the component feed unit 6, it is possible to concurrently arrange the plurality of suction nozzles 3 above the plurality of component pickup positions 7a, and it is possible to concurrently hold and pick up a plurality of components 1 by means of the plurality of the suction nozzles 3.

(Component Mounting Operation by Component Mounting Apparatus)

The mounting operation of each of the components 1 onto the board 2 executed in the component mounting apparatus 100 of the aforementioned construction will be described next. It is to be noted that the mounting operation is executed while being controlled by the control system in the component mounting apparatus 100.

First of all, in the component mounting apparatus 100 shown in Fig. 1, the board 2 onto which the components 1 are to be mounted is supplied to the board conveyance unit 9, conveyed from the right-hand side to the left-hand side in the illustrated X-axis direction by the board conveyance unit 9 and releasably held by the stage 5. Onto the board 2 thus supplied to the board conveyance unit 9 is supplied with a bonding material of solder or the like by printing or similar means in order to allow the components 1 to be bonded to, for example, a plurality of electrodes (not shown) formed on the surface of the board 2. By mounting the components 1 on the electrodes of the board 2 with interposition of the bonding material in the component mounting apparatus 100, electrical continuity between the components 1 and the electrodes of the board 2 can be obtained.

Next, the movement operation of the head unit 4 toward a place above the component feed unit 6 is started by the X-Y robot 8. In parallel with this movement operation of the head unit 4, a preparatory descent operation of one or a plurality of the suction nozzles 3 that picks up the component or components 1 by suction and holding is started in the head unit 4. With regard to this preparatory descent operation, the tip portion of the suction nozzle 3 is moved down to a height position where

the tip portion does not interfere with the other constituent sections arranged on the machine table 10 of the component mounting apparatus 100, in order to shorten the time necessary for the holding and pickup in holding and picking up the component 1 by the suction nozzle 3 and put into a descent standby state with the height position served as a descent standby height position (also as one example of the component holding standby height position). Further, in parallel with this movement operation of the head unit 4 and the preparatory descent operation of the one or the plurality of suction nozzles 3, there is started operation to feed the component 1 to the component pickup position 7a in the one or the plurality of component feed cassettes 7 where the holding and pickup of the components 1 are performed in the component feed unit 6.

Subsequently, the movement operation of the head unit 4 by the X-Y robot 8 is completed, and the one or the plurality of suction nozzles 3 are positioned above the component pickup position 7a of the one or the plurality of component feed cassettes 7. Also, the component 1 positioned in the component pickup position 7a in each of the one or the plurality of component feed cassettes 7 is brought into a state in which it can be picked up by, for example, opening a shutter (not shown) or exposing the stored component 1 by peeling off the cover tape that

covers the carrier tape. Further, together with these operations, the descent operation of the one or the plurality of suction nozzles 3 put in the descent standby state is started in the head unit 4. When the tip portions of the one or the plurality of suction nozzles 3 are brought in contact with the upper surface of the respective components 1, the sucking and holding is performed in accordance with the action. Subsequently, the ascent operation of the suction nozzles 3 is started to hold and pick up the components 1 from the respective component feed cassettes 7. To subsequently further perform the pickup of a component 1 by another suction nozzle 3 provided for the head unit 4, the pickup can be performed by repeating the above-mentioned operation.

Next, the upward movement operation of the board 2 by the X-Y robot 8 is started in the head unit 4. Moreover, together with this movement operation of the head unit 4, the preparatory descent operation of the suction nozzle 3 that first performs the mounting operation of the component 1 is started to put the nozzle in the descent standby state in the descent standby height position. Subsequently, the positional alignment of the component 1 sucked and held by the suction nozzle 3 with the mounting position of the component 1 on the board 2 is performed by the movement operation of the head unit 4 by the X-Y robot

8. Then, the suction nozzle 3 is further moved down from the descent standby height position to mount the component 1 in the mounting position of the board 2. Subsequently, the suction and holding of the component 1 by the suction nozzle 3 is released, in accordance with which the suction nozzle 3 is moved up. When the components 1 held by the other suction nozzles 3 of the head unit 4 are mounted onto the board 2, the mounting can be achieved by repeating the above-mentioned operation.

Subsequently, by repetitively executing the aforementioned component holding and pickup operation and component mounting operation a plurality of times, a plurality of components 1 are mounted on the board 2. The board 2 on which the components 1 are mounted is released from the holding by the stage 5, conveyed leftward in the illustrated X-axis direction by the board conveyance unit 9 and ejected from the component mounting apparatus 100.

Although not shown in Fig. 1, there may be the case where a component imaging device that is able to capture the image of the component 1 in the held state in which it is picked up from the component feed cassette 7 and sucked and held by the suction nozzle 3 is provided on the upper surface of the machine table 10. In the above case, the state in which the component 1 is held by the suction nozzle 3 can be recognized on the basis of the

image captured by the component imaging device, and the posture of the held component 1 can be corrected on the basis of the result of recognition.

Moreover, each of the suction nozzles 3 provided for the head unit 4 may be rotatable around the center of axis thereof. In the above case, the rotational movement is performed on the basis of the mounting position and the posture of the component 1 on the board 2 before the mounting operation after the component 1 is held and picked up.

(Construction of Control System)

The construction of the control system provided for the component mounting apparatus 100 will be described next. The control system provided for the component mounting apparatus 100 does not adopt the "centralized control system" that intensively controls the operation of a plurality of constituent sections by one control unit as in the control system of the conventional component mounting apparatus but adopts the "distributed control system" that executes the control of the constituent sections by individually providing the constituent sections themselves with a control unit called the distribution unit, making the distributed units dialog (i.e., communicate) one another and executing the control of the constituent sections while correlating them with one another. Fig. 3

shows a control block diagram schematically showing the construction of a distributed control system 101 that is one example of the above-mentioned control system. In the control block diagram shown in Fig. 3, only the principal constituent sections provided for the distributed control system 101 are shown for the sake of easy understanding of the explanation of the construction. Therefore, the detailed construction of the distributed control system 101 should not be interpreted as limited to the one shown in Fig. 3.

As shown in Fig. 3, the distributed control system 101 is provided with a head distribution unit 40 as one example of the head unit control section that is provided for the head unit 4 and controls the operation in the head unit 4, a component feed distribution unit 50 as one example of the component feed unit control section that is provided for the component feed unit 6 and controls the operation in the component feed unit 6 and an X-Y robot distribution unit 60 as one example of the moving unit control section that is provided for the X-Y robot 8 and controls the operation in the X-Y robot 8. Moreover, the distributed control system 101 is provided with an MMC 30 as one example of the main control section that plays the generalized role of the control of the distribution units (this is the general term for the head distribution unit 40,

the component feed distribution unit 50 and the X-Y robot distribution unit 60, and so forth hereinafter). Between the MMC 30 and each of the distribution units is provided a communication control section 35 (e.g., CAN communication control section) that is one example of the distribution unit and controls communications of information between the MMC 30 and each of the distribution units (serving as a communication interface). In contrast to the arrangement that the distribution units are provided for the respective constituent sections (e.g., head unit) provided for the component mounting apparatus 100, the MMC 30 is provided on the main body side of the component mounting apparatus 100.

Moreover, a serial bus communication standard called CAN (Controller Area Network) is used as one example for the information communications in the distributed control system 101. By using this CAN, it becomes possible to execute one-to-many (i.e., master to the others) communications with either one of the distribution units or the MMC 30 served as the master. Moreover, by filtering the message of information to be transferred in the input/output section on the reception side, it becomes possible to execute one-to-one pseudo-communications. That is, it becomes possible to execute communications of information as if a dialog is established between each of the distribution units and the MMC 30, and this is suitable

for the transmission of a recipe and an event as described later. In the case where only one distribution unit is provided for the distributed control system, the one-to-many communications as described above is not necessary. Therefore, it is possible to adopt a one-to-one serial communication system like RS422.

As shown in Fig. 3, the MMC 30 is provided with a recipe forming section 33 that forms recipes of an operation program for executing motion control executed in each of the distribution units and an input/output (I/O) section 32 as one example of a recipe transmission section that is able to transmit each of the formed recipes to the distribution units through the communication control section 35 and receive the information transmitted from the distribution units through the communication control section 35. Further, the MMC 30 is provided with a main memory section 34 that retrievably stores the recipes formed in the recipe forming section 33, the information inputted from the input/output section 32 and so on and a main CPU 31 that executes the centralized control of the operations of the recipe forming operation in the recipe forming section 33, the input and output in the input/output section 32 and data storage, read and so on in the main memory section 34.

Moreover, as shown in Fig. 3, the head

distribution unit 40 is provided with an input/output section 42 that is able to input (receive) information of recipes and so on transmitted from the MMC 30 and output (transmit) information to the other distribution units and the MMC 30 and a memory section 43 that retrievably stores the information and data of the recipe and so on. Further, the head distribution unit 40 is provided with a head CPU 41 that has a function as a recipe executing section for executing the transmitted recipe, a head driver 45 that controls the driving of the operation in the head unit 4 on the basis of the execution of the recipe and a sensor section 44 that detects the amount of drive of the actual operation in the head unit 4. It is to be noted that the head CPU 41 controls the amount of drive by the head driver 45 on the basis of the amount of drive detected by the sensor section 44.

Further, in the head distribution unit 40, the head CPU 41 has functions to form a timing signal called the "event" of a signal that represents the operation state on the basis of the detection result of the sensor section 44 of the amount of drive control of the head unit 4 based on the execution of the recipe and transmit the formed event from the input/output section 42 to the other distribution units (i.e., also having a function as an event forming section or a timing signal forming section).

Moreover, the head CPU 41 also has a function to start or end the execution of the recipe stored in the memory section 43 on the basis of the event that has been formed by another distribution unit and transmitted.

Moreover, as shown in Fig. 3, the distribution units other than the head distribution unit 40 have similar constructions.

The component feed distribution unit 50 is provided with a component feed CPU 51 that executes the recipes and forms the events, a component feed driver 55 that performs the drive control of the operation of the component feed unit 6, a sensor section 54 that detects the actual amount of drive of the component feed unit 6, a memory section 53 that retrievably stores data of the recipe and so on and an input/output section 52 that transmits and receives the information of the recipe, event and so on. It can be considered the case where there exists no motor or the like to be driven in the component feed unit 6. In the above case, it may be the case where the component feed driver 55 is not provided for the component feed distribution unit 50.

The X-Y robot distribution unit 60 is provided with an X-Y robot CPU 61 that executes the recipes and forms the events, an X-Y robot driver 65 that executes the drive control of the operation of the X-Y robot 8, a sensor

section 64 that detects the actual amount of drive of the X-Y robot 8, a memory section 63 that retrievably stores the data of the recipe and so on and an input/output section 62 that transmits and receives the information of the recipe, event and so on.

By providing, for example, an IC that has a CAN communication function for each of the input/output sections 32, 42, 52 and 62, it becomes possible to execute the CAN communications in the distributed control system 101.

Although the CAN communications are performed as described above in the distributed control system 101 according to the above description, the present invention is not limited only to the above case. For example, it may be the case where communications other than CAN are used.

(Contents of Motion Control in the Component Mounting Apparatus)

Next, before describing the control operation to be executed in the distributed control system 101 that has the aforementioned construction, the contents of a plurality of operations (or processes) for the component mounting executed in the component mounting apparatus 100 will be described with reference to the flow chart that shows the component mounting procedure shown in Fig. 4.

The flow chart shown in Fig. 4 shows the

operation of the head unit 4 (flow shown in the center column of the flow chart of Fig. 4), the operation of the component feed unit 6 (flow shown in the left-hand column of the same figure) and the operation of the X-Y robot 8 (flow shown in the right-hand column of the same figure), during which the component 1 fed from the component feed unit 6 is held and picked up by the head unit 4, transferred by the X-Y robot 8 and mounted onto the board 2.

First of all, paying attention to the operation of the head unit 4, the operation performed by the head unit 4 during the component mounting includes mainly two processes. One process is a "component holding and pickup process" in which the operation of sucking and holding the component 1 by the suction nozzle 3 to pick up the component from the component feed cassette 7 is executed. The other process is a "component mounting process" in which the operation of mounting the component 1 that has been sucked and held onto the board 2 is executed. In the present first embodiment, the component holding and pickup process is one example of the component holding and pickup operation, and the component mounting process is one example of the component mounting operation.

Further, as shown in Fig. 4, this component holding and pickup process includes a "component holding preparation operation" (step S1) that is the aforementioned

preparatory descent operation of the suction nozzle 3 and a "component holding main operation" (step S2) that is the operation of sucking and holding the component 1 by further moving down the suction nozzle 3 positioned in the descent standby height position as a consequence of the execution of the preparatory descent operation and thereafter picking up the component 1 by moving up the nozzle. If the above component holding and pickup process (i.e., steps S1 and S2) is executed, then it is determined in step S3 whether or not to execute the next component holding and pickup process, and the steps S1 and S2 are repeated until the component holding and pickup process to be executed is entirely completed. When the process is entirely completed, the component mounting process is started.

Moreover, as shown in Fig. 4, the component mounting process includes a "component mounting preparation operation" (step S4) that is the preparatory descent operation of the suction nozzle 3 in the state in which it is holding the component 1 and a "component mounting main operation" (step 5) that is the operation of executing the mounting of the component 1 by further moving down the suction nozzle 3 positioned in the descent standby height position as a consequence of the execution of the preparatory descent operation so as to bond the component 1 onto the board 2, releasing the suction and holding by the

suction nozzle 3 and moving up the suction nozzle 3. If the above component mounting process (i.e., steps S4 and S5) is executed, then it is determined in step S6 whether or not to execute the next component mounting process, and the steps S4 and S5 are repeated until the component mounting process to be executed is entirely completed. When the process is entirely completed, the operation by the head unit 4 is completed.

Next, paying attention to the operation of the component feed unit 6, a "component feed process" for retrievably feeding a component 1 from the component feed unit 6 during the component mounting is executed in the component feed unit 6. In the present first embodiment, the component feed process is one example of the component feed operation. As shown in Fig. 4, the component feed process includes a "component feed preparation operation" (step S11) represented by the feed operation of the component 1 to the aforementioned component pickup position 7a (or its neighborhood) in the component feed cassette 7 and a "component feed main operation" (step S12) that is the operation of positioning the component 1 positioned in the component pickup position 7a (or its neighborhood) into a state in which the component can be picked up by, for example, opening the shutter (or opening the shutter by positioning the component from the neighborhood into the

component pickup position 7a or a similar process). If the above component feed process (i.e., steps S11 and S12) is executed, then it is determined in step S13 whether or not to execute the next component feed process, and the steps S11 and S12 are repeated until the component feed process to be executed is entirely completed. When the process is entirely completed, the component feed process is completed, and the operation by the component feed unit 6 is completed.

Next, paying attention to the operation of the X-Y robot 8, the operation to be executed by the X-Y robot 8 during the component mounting includes mainly two processes. One process is a "head moving process for the component holding and pickup process" (step S21) that is the operation of moving the head unit 4 toward a place above the component feed unit 6. The other process is a "head moving process for the component mounting process" (step S23) that is the operation of moving the head unit 4 toward a place above the board 2. In the present first embodiment, the head moving process for the component holding and pickup process is one example of the head moving operation for the component holding and pickup operation, and the head moving process for the component mounting process is one example of the head moving operation for the component mounting operation.

As shown in Fig. 4, if the head moving process

for the component holding and pickup process is executed in step S21, then it is determined in step S22 whether or not to execute the head moving process for the next component holding and pickup, and the step S21 is repeated until the process to be executed is entirely completed. When the process is entirely completed, the head moving process (step S23) for the component mounting process of the next process is started.

If the head moving process for the component mounting process is executed in step S23, then it is determined in step S24 whether or not to execute the head moving process for the next component mounting process, and the step S23 is repeated until the process to be executed is entirely completed. When the process is entirely completed, the operation by the X-Y robot 8 is completed.

(Control Operation of the Distributed Control System)

Principal control operation during the component mounting in the aforementioned distributed control system 101 will be described next.

(Control Operation during the Component Holding and Pickup Process)

First of all, a schematic explanatory flow chart schematically showing the information communications, i.e., the transfer state of the recipes and the events between the MMC 30, the head distribution unit 40 and the component

feed distribution unit 50 when the component holding and pickup process of components 1 from the component feed unit 6 by the head unit 4 is executed is shown in Figs. 5 and 6, and a flow chart of the operation procedure is shown in Fig. 7. A plurality of recipes and events are handled in the following description. The plurality of recipes are indicated by R1 through R3, and the plurality of events are indicated by I1 through I7. Moreover, in Figs. 5 and 6, when the ten suction nozzles 3 provided for the head unit 4 are used specified, for example, the suction nozzle 3-1 is indicated by "N = 1" as the nozzle number. When the six component feed cassettes 7 provided for the component feed unit 6 are used specified, for example, the component feed cassette 7-2 is indicated by "Z = 2" as the cassette number.

First of all, the plurality of recipes to be executed in the head distribution unit 40 and the component feed distribution unit 50 by the MMC 30 are formed in step S31 in Fig. 7, and the formed recipes are transmitted from the MMC 30 to the distribution units 40 and 50 in step S32.

Referring to a concrete example for explanation, as shown in Fig. 5, in the case where components 1 are held and picked up by the one or the plurality of suction nozzles 3 provided for the head unit 4 by executing the component holding and pickup process three times and thereafter the component mounting process is executed by

the head unit 4, there is the practice of forming a recipe every component holding and pickup process, i.e., forming three recipes R1, R2 and R3 in the MMC 30.

The recipe R1 for the component feed process transmitted to the component feed distribution unit 50 is formed containing the information of the cassette number like, for example, "Z = 1, 2, 3" (indicating the component feed cassettes 7-1, 7-2 and 7-3 in this case) so that the component feed cassettes 7 (or the component pickup positions 7a) from which the components 1 are to be picked up during the component holding and pickup process executed at the first time can be recognized by the component feed distribution unit 50. Likewise, the recipe R2 is formed containing the information of the number of the cassette from which the components 1 are to be picked up in the next component holding and pickup process like "Z = 4, 5", and the recipe R3 is formed containing the information of "Z = 1, 3, 5".

On the other hand, the recipe R1 for the component holding and pickup process transmitted to the head distribution unit 40 is formed containing the information of the nozzle number like, for example, "N = 1, 2, 3" (indicating the suction nozzles 3-1, 3-2 and 3-3 in this case) so that the suction nozzles 3 to suck and hold the components 1 during the component holding and pickup

process executed at the first time can be recognized by the head distribution unit 40. Likewise, the recipe R2 is formed containing the information of "N = 4, 5", and the recipe R3 is formed containing the information of "N = 6, 8, 10". Moreover, the recipes R1 through R3 transmitted to the head distribution unit 40 further contain the information of the cassette number as to which component feed cassettes 7 the suction nozzles 3 pick up the components 1 from as shown in Fig. 5 in addition to the information of the nozzle numbers.

Moreover, with regard to the sequence of transmitting the recipes from the MMC 30 to the head distribution unit 40 and the component feed distribution unit 50, priority may be given to either of them. However, with regard to the entire component mounting operation, considering the fact that the component feed unit 6 executes only the component feed process in contrast to the fact that the head unit 4 is required to execute the two processes of the component holding and pickup process and the component mounting process, it is preferable to first execute the recipe transmission to the head distribution unit 40 in terms of reducing the influence of the time required for the recipe transmission exerted on the component mounting and achieving more efficient recipe transmission.

Next, as shown in Fig. 7, the execution of the recipe R1 to be executed first out of the received recipes R1 through R3 is started in the head distribution unit 40 in step S33, and the execution of the recipe R1 to be executed first out of the received recipes R1 through R3 is started in the component feed distribution unit 50 in step S40. In each of the distribution units 40 and 50, the start of the recipe R1 may be executed by determining whether or not the start is permitted by the corresponding CPU 41 or 51 on the basis of received recipe R1. Otherwise, the start may be executed by transmitting a command signal for starting the first recipe R1 from the MMC 30 to each of the distribution units 40 and 50 aside from the transmission of the recipes R1 through R3.

Subsequently, as shown in Fig. 7, the component holding preparation operation is started in the head distribution unit 40 on the basis of the recipe R1 (step S34). In concrete, the descent operation of the suction nozzles 3 of the nozzle numbers N = 1, 2 and 3 to the descent standby height position is started by the information of the nozzle numbers contained in the recipe R1. On the other hand, in the component feed distribution unit 50, the component feed preparation operation is started on the basis of the recipe R1 (step S41). In concrete, the feed operation of the components 1 to the

component pickup positions 7a is started in the component feed cassettes 7 of the cassette numbers Z = 1, 2 and 3 by the information of the cassette numbers contained in the recipe R1. Subsequently, it is determined in step S42 whether or not the component feed preparation operation is completed, i.e., whether or not the components 1 are positioned in the component pickup positions 7a in the component feed cassettes 7, and the operation is continuously executed until the above operation is completed. If it is confirmed that the operation is completed, then the component feed cassettes 7 are put in a standby state in step S43.

In the head distribution unit 40, it is determined in step S35 whether or not the component holding preparation operation is completed, i.e., whether or not the suction nozzles 3 have been moved down to the descent standby height position, and the operation is continuously executed until the completion. If it is confirmed that the operation is completed, then the event I1 is transmitted from the head distribution unit 40 to the component feed distribution unit 50 in step S36, making the component feed distribution unit 50 recognize the completion of the operation. After the event I1 is transmitted, the head distribution unit 40 is put in the standby state (step S37).

On the other hand, in the component feed

distribution unit 50, the standby state is continued until the event I1 is received from the head distribution unit 40 (step S44). If the event I1 is received, then the component feed main operation is executed on the basis of the recipe R1 (step S45). Concretely, in order to allow the component 1 positioned in the component pickup position 7a in each of the component feed cassettes 7 to be picked up by the suction nozzle 3, the operation of, for example, putting the shutter that protects the component 1 into an open state. Subsequently, when the component feed main operation is completed, the event I2 for transmitting the information of the event that the component 1 is put in the state in which it can be picked up in each of the component feed cassettes 7 is transmitted from the component feed distribution unit 50 to the head distribution unit 40 (step S46). The reason for the start of the component feed main operation after the reception of the event I1 in the component feed cassette 7 is as follows. That is, for example, if the component feed main operation for opening the shutter or peeling off the cover tape is executed, the component 1 can be put into the state in which it can be picked up, whereas the component 1 is put in a state in which it is more prone to the external influence. Therefore, the possibility that the component 1 may receive the influence is reduced by shortening the duration of this

state as far as possible. By so doing, the accuracy of holding and picking up the component 1 can be improved.

In the head distribution unit 40, if the reception of the event I2 is confirmed in step S38, then the standby state until then is released, and the component holding main operation is executed on the basis of the recipe R1 (step S39). In concrete, the suction nozzles 3-1, 3-2 and 3-3 positioned in the descent standby height position are further moved down to suck and hold the components 1 in the component pickup positions 7a of the respective component feed cassettes 7-1, 7-2 and 7-3 and thereafter moved up to execute the holding and pickup operation of the components 1. As described above, by starting the execution of the component holding main operation upon receiving the event I2, it becomes possible to subject the components 1, which are allowed to be reliably held and picked up, to the above operation and previously prevent the occurrence of an error such as interference with the component feed cassettes 7 due to the descent of the suction nozzles 3.

Subsequently, it is determined in step S47 whether or not to execute the next recipe. With regard to the already received recipe R2, the recipe R2 is executed similarly to the aforementioned procedure in the head distribution unit 40 and the component feed distribution

unit 50. As shown in Fig. 6, in executing the component holding and pickup process based on this recipe R2, the suction and holding and pickup of components 1 from the component feed cassettes 7 of the "cassette numbers Z = 4, 5" by the suction nozzles 3 of the "nozzle numbers N = 4, 5" is executed. Moreover, in executing the component holding and pickup process based on the subsequent recipe R3, the suction and holding and pickup of components 1 from the component feed cassettes 7 of the "cassette numbers Z = 1, 3, 5" by the suction nozzles 3 of the "nozzle numbers N = 6, 8, 10" is executed. If the execution of the recipe R3 in the head distribution unit 40 is completed, then the event I7 for transmitting the information of the completion is transmitted from the head distribution unit 40 to the MMC 30, and it is recognized that the component holding and pickup process based on all the recipes R1 through R3 is completed in the MMC 30.

As shown in Fig. 5, the event transferred between the head distribution unit 40 and the component feed distribution unit 50 may be executed by transferring the plurality of events I1 through I6 as shown in Fig. 6 instead of transferring one event I1 and one event I2 as shown in Fig. 5. For example, the contents and the transmission timing of the aforementioned events I1 through I6 will be described in relation to the tip height position

of the suction nozzle 3 shown in Fig. 8. Fig. 8 shows the relation between tip height positions H0 through H2 and time T0 to T5 when an arbitrary suction nozzle 3 executes the component holding and pickup process.

As shown in Fig. 8, the suction nozzle 3 positioned in the upper end height position H2 in the elevation height position (or elevation position) is moved down during the time divisions T0 through T1 and positioned in the descent standby height position H1 at the time T1. At this time, for example, the event I1 is transmitted to transfer this information to the component feed distribution unit 50. Upon receiving this event I1, the component feed distribution unit 50 can start the component feed main operation.

Subsequently, during the time divisions T2 to T3, the suction nozzle 3 is moved down from the descent standby height position H1 to the suction and holding height position H0, and the suction and holding of the component 1 is executed. In accordance with the timing of this time T2, the event I3 intended for transferring, for example, the information that the final descent from the descent standby height position H1 starts is transmitted. The above is because it is required to execute the final operation for putting the component 1 into a state in which the component can be held by peeling off the cover tape immediately

before the suction and holding depending on the type of the components 1 accommodated in the component feed cassette 7.

The suction nozzle 3, which is sucking and holding the component 1, starts moving up at the time T4, and if the nozzle is positioned in the upper end height position H2, then, for example, the event I5 that transfers the information of this state, is transmitted to the component feed distribution unit 50. In the component feed distribution unit 50 that has received this event I5, the feed operation of the next component 1 can be started on the basis of this event I5. In the component feed distribution unit 50 that has received the events I1, I3 and I5, certain operation may be executed on the basis of each of the events. When no operation is necessary depending on the type of the accommodated component 1, the operation may not be executed. The necessity or nonnecessity of the operation is determined by the component feed CPU 51 on the basis of the received recipe. Moreover, when certain operation is executed on the basis of the received events I1, I3 and I5, the component feed distribution unit 50 may transmit the events I2, I4 and I6 based on the operation to the head distribution unit 40 as shown in Fig. 6.

Moreover, the component feed distribution unit 50 may be further provided with a recipe integration section

56 that has a function to integrate a plurality of recipes on the basis of the contents as shown in the block diagram of Fig. 9 in place of the construction of the block diagram shown in Fig. 3. In the above case, for example, the "cassette numbers Z = 1, 2, 3" in the recipe R1 and the "cassette numbers Z = 4, 5" in the recipe R2 received by the component feed distribution unit 50 are integrated by the recipe integration section 56. The feed operation of the components 1 is simultaneously executed in the component feed cassettes 7 of the "cassette numbers Z = 1, 2, 3, 4, 5" according to the integrated recipe of the recipes R1 and R2, allowing more efficient component feed operation to be executed.

(Operation to Cope with Error Generated in the Component Holding and Pickup Process)

An example of control operation to cope with an operation error generated after the recipes R1 through R3 are transmitted from the MMC 30 to each of the head distribution unit 40 and the component feed distribution unit 50 during the component holding and pickup process will be described with reference to the schematic flow chart shown in Fig. 10.

As shown in Fig. 10, when, for example, component depletion occurs as the aforementioned operation error in the component feed cassette 7-5 of the cassette number Z =

5 in the component feed unit 6, the error information of component depletion is transmitted from the component feed distribution unit 50 to the head distribution unit 40 and the MMC 30. In the case where, for example, the recipes R1 and R2 have been executed and the recipe R3 has not yet been executed in the head distribution unit 40 that has received this error information, it is determined that the information of the "cassette numbers Z = 1, 3, 5" of the received recipe R3 and the error information of the "component depletion cassette number Z = 5" overlap with each other by the head CPU 41, and the execution of the recipe R3 is awaited for the start.

On the other hand, the MMC 30 comprehensively determines the component feed cassette 7 that accommodates the components 1 of the same type as that of the component feed cassette 7-5 of the cassette number Z = 5 where the component depletion has occurred, the nozzle number of the suction nozzle 3 that performs the suction and holding and so forth on the basis of the error information, corrects the recipe R3 as, for example, a recipe R3a (correction is executed in the recipe forming section 33) and transmits the resulting recipe to the distribution units 40 and 50 (transmission from the input/output section 32).

In concrete, the MMC 30 preparatorily receives the input of information capable of recognizing in advance

the type and characteristics of the components 1 accommodated in the component feed cassettes 7 in the component feed unit 6 correspondingly by, for example, the main memory 34 shown in Fig. 3 or a database or the like (not shown in Fig. 3). Upon receiving the error information, the main CPU 31 retrieves the information of the component feed cassette 7 from the main memory 34 or the database and determines which component feed cassette 7 accommodates the components 1 of the same type and same characteristics as those of the components 1 stored in the component feed cassette 7-5 or the components 1 that can be used as a substitute. The recipe R3 is corrected to the recipe R3a in the recipe forming section 33 on the basis of the result of determination, and the recipe R3a is transmitted from the input/output section 32 to the distribution units 40 and 50.

As a result, the information of, for example, "the nozzle numbers N = 6, 8, 10 and the cassette numbers Z = 2, 4, 6" is transmitted as the corrected recipe R3a to the head distribution unit 40, while the information of "the cassette numbers Z = 2, 4, 6" is transmitted as the corrected recipe R3a to the component feed distribution unit 50. Subsequently, the already received previous recipe R3 is replaced by the corrected recipe R3a and each operation is executed on the basis of the corrected recipe

R3a in the distribution units 40 and 50.

If the MMC 30 determines that the already transmitted recipe cannot be corrected on the basis of the transmitted error information, then the MMC 30 may transmit a signal to skip the execution of the recipe to the distribution units 40 and 50 or form and transmit a new recipe to the distribution units 40 and 50.

(Control Operation in the Component Mounting Process)

Next, a schematic explanatory flow chart schematically showing the information communications, i.e., the transfer state of recipes and events between the MMC 30, the head distribution unit 40 and the X-Y robot distribution unit 60 when the component mounting process of the components 1 held by the head unit 4 onto the board 2 is executed is shown in Fig. 11, and a flow chart of the operation procedure is shown in Fig. 12. Moreover, a chart of the relation between the operation of the X-Y robot 8 and the operation of the suction nozzle 3 for explaining the transmission timing of the events that are transmitted and received between the head distribution unit 40 and the X-Y robot distribution unit 60 is shown in Fig. 13.

A relation between the movement operation of the head unit 4 by the X-Y robot 8 and the elevation operation of the suction nozzle 3 for the component mounting will be described first with reference to the schematic explanatory

view shown as one example in Fig. 13. In Fig. 13, the upper row shows a relation between the occurrence of the X-Y movement of the head unit 4 by the X-Y robot 8 and the time, while the lower row shows a relation between the tip height position of the suction nozzle 3 during the elevation operation for the component mounting in the head unit 4 and the time. For the sake of easy understanding of the relation between the upper row and the lower row, the time (time T0 to T6) base is shown in common.

As shown in Fig. 13, the head unit 4 is moved in the X-axis direction or the Y-axis direction (hereinafter assumed as the X-Y movement) toward a place above the mounting position of the component 1 on the board 2 by the X-Y robot 8, and the suction nozzle 3 that performs the component mounting arrives at a region called a "timing zone" that is a position (prescribed region) within a prescribed range in the vicinity of the mounting position inclusive at the time T0 with the travel speed thereof decelerated. If the arrival at this timing zone is recognized by the head distribution unit 40 by the transmission of the event describes later, then the descent of the suction nozzle 3 positioned in the upper end height position H2 of the elevation is started, and the descent is temporarily stopped when the nozzle is positioned in the descent standby height position H1 at the time T1.

Subsequently, if the suction nozzle 3, which is continuing the X-Y movement, arrives at the component mounting position at the time T2, then the movement of the head unit 4 by the X-Y robot 8 is stopped. If the arrival at this component mounting position is recognized by the head distribution unit 40 by the transmission of the event described later, then the descent of the suction nozzle 3 positioned in the descent standby height position H1 is started and positioned in the lower end height position H0 at the time T3, and the component 1 that is sucked and held is bonded to the component mounting position of the board 2. Subsequently, the suction and holding of the component 1 by the suction nozzle 3 is released, and the ascent of the suction nozzle 3 is started at the time T4. If the event that the suction nozzle 3 has arrived at the descent standby height position H1 at the time T5 is recognized by the X-Y robot distribution unit 60 by the transmission of an event or the like, then the movement of the head unit 4 by the X-Y robot 8 is started. Subsequently, the suction nozzle 3 is positioned in the upper end height position H2 at the time T6.

A method for determining (setting) the timing zone is described here. In order to shorten the time to be spent on the operation of the component mounting, it is desired to keep the height of the suction nozzle 3 during

the X-Y movement as low as possible and reduce the amount of descent of the suction nozzle 3 after the arrival at the component mounting position. However, in order to perform the mounting of the component 1 on the board 2, for example, after the process of picking up the component from the component feed unit 6, the X-Y movement is required to be performed with the suction nozzle 3 elevated to the height position where obstacles such as the conveyance rails of the board conveyance unit 9 and so on located between the component pickup position 7a and the component mounting position do not interfere with the suction nozzle 3 and the component 1 that is sucked and held. The timing zone is determined taking the positions of those obstacles and the size of the component 1 that is being sucked and held by the suction nozzle 3 into account. By detecting the arrival at this timing zone, it is possible to recognize the fact that the suction nozzle 3 has been moved into the area above the board 2, where the suction nozzle 3 can be securely moved down to the descent standby height position H1.

It is to be noted that this timing zone is not always necessary. For example, in the case where the mechanically highest position is the conveyance rails on the machine table 10 and the height of the component 1 already mounted on the board 2 is higher than the

conveyance rails, the suction nozzle 3 cannot be moved down because the nozzle has moved over the conveyance rails. In the above case, the suction nozzle 3 is moved down from H2 to H0 in one operation when the timing zone = 0 (zero), i.e., after the suction nozzle 3 has arrived at the component mounting position.

Reference is made by using the schematic explanatory flow chart of Fig. 11 and the flow chart of Fig. 12.

First of all, the recipes to be executed by the head distribution unit 40 and the X-Y robot distribution unit 60 are formed in the MMC 30 in step S51 of Fig. 12, and the formed recipes are transmitted from the MMC 30 to the distribution units 40 and 60 in step S52.

Referring to a concrete example for explanation, as shown in Fig. 11, in the case where, for example, components 1 are held by a plurality of suction nozzles 3 in the head unit 4, recipes R11 and R12 are formed every component mounting process executed by the suction nozzles 3 and transmitted before the start of each component mounting process.

The recipe R11 for the component mounting process transmitted to the head distribution unit 40 includes the information of the nozzle number like, for example, "N = 1" so that the suction nozzle 3 that first executes the

component mounting process can be recognized by the head distribution unit 40. Likewise, the recipe R12 to be executed next includes the information of "N = 2".

On the other hand, the recipe R11 for the head moving process transmitted to the X-Y robot distribution unit 60 includes the position information of the mounting position on the board 2 of the component 1 held by the suction nozzle 3 that first executes the component mounting process (or the position information of the relocation position for the movement to the mounting position) like, for example, "(X, Y)" in the form of the X-Y coordinates, and the recipe R12 also includes information in the similar form.

Moreover, with regard to the sequence of transmitting the recipes from the MMC 30 to the distribution units 40 and 60, priority may be given to either of them. However, considering the fact that the component mounting with the descent of the suction nozzle 3 cannot be performed unless the X-Y movement is performed so that the head unit 4 is positioned above the component mounting position, it is preferable to first execute the recipe transmission to the X-Y robot distribution unit 60 in terms of more efficiently executing the component mounting.

Next, as shown in Fig. 12, the execution of the

received recipe R11 is started in the X-Y robot distribution unit 60 in step S58, and the execution of the received recipe R11 is started in the head distribution unit 40 in step S53. The start of the recipe R11 in the distribution units 40 and 60 may be executed after determining whether or not the start is permitted by the CPU 41 or 61 on the basis of the received recipe R11. Otherwise, the start may be executed by transmitting a command signal for starting the recipe R11 from the MMC 30 to the distribution units 40 and 60 aside from the transmission of the recipe R11.

Subsequently, as shown in Fig. 12, the head moving process for the component mounting process is started in the X-Y robot distribution unit 60 on the basis of the recipe R11 (step S59). In concrete, the X-Y movement by the X-Y robot 8 is started so that the head unit 4 is positioned above the component mounting position. Subsequently, if it is confirmed that the head unit 4 has arrived at the inside of the timing zone by the X-Y movement (step S60), then the event I11 is transmitted from the X-Y robot distribution unit 60 to the head distribution unit 40 for the purpose of transmitting the information of the arrival (step S61).

On the other hand, in the head distribution unit 40, the start of operation based on the recipe R11 is in

the standby state until the event I11 from the X-Y robot distribution unit 60 is received in step S54. Upon receiving the event I11, the execution of the component mounting preparation operation is started on the basis of the recipe R11. In concrete, the suction nozzle 3 of the nozzle number N = 1 is moved down from the upper end height position H2 to the descent standby height position H1.

Together with the above operation, in the X-Y robot distribution unit 60 that is continuously executing the control of the X-Y movement, it is determined whether or not the suction nozzle has arrived at the place above the component mounting position (step S62). If the arrival is determined, the event I12 for transferring the information of the arrival is transmitted to the head distribution unit 40.

In the head distribution unit 40, the descent of the suction nozzle 3 is put in the standby state in the descent standby height position H1 until the event I12 is received in step S56. Upon receiving the event I12, the execution of the component mounting main operation is started on the basis of the recipe R11 (step S57). In concrete, the suction nozzle 3 of the nozzle number N = 1 is moved down from the descent standby height position H1 to the lower limit height position H0, and the component 1 that is sucked and held is bonded to the component mounting

position of the board 2. Subsequently, the suction nozzle 3 is moved up with the suction and holding of the component 1 by the suction nozzle 3 released, and the component 1 is mounted on the board 2.

Subsequently, it is determined whether or not to receive and execute the next recipe in step S64. When the recipe is executed, the aforementioned procedure is repeated. When the recipe is not executed, the component mounting process ends.

Instead of determining whether or not the execution of the next recipe is permitted in step S64 as described above, the MMC 30 may transmit the next recipe R12 to the X-Y robot distribution unit 60 after the execution of step S63 as shown in Figs. 11 and 12. In the above case, as shown in Fig. 11, an event I13 is transmitted from the head distribution unit 40 to the X-Y robot distribution unit 60 for the purpose of transferring the information when the elevating suction nozzle 3 is moved up to the descent standby height position H1 after the mounting of the component 1, and the execution of the next recipe R12 can be started on the basis of the reception of the event I13 in the X-Y robot distribution unit 60, allowing the component mounting process to be executed more efficiently. Subsequently, the next recipe R12 is further transmitted from the MMC 30 to the head

distribution unit 40 put in the state in which the first component mounting process is completed, and the recipe R12 is executed awaiting for the reception of the event I11 from the X-Y robot distribution unit 60. If the component mounting process based on the recipe R12 is completed in the head distribution unit 40, then an event I14 is transmitted to the MMC 30, making it possible to transfer the completion of the component mounting process based on the recipe R12.

Moreover, in the case where an error is detected during the control operation in either the distribution units 40 or 60 when the component mounting process is executed, by transmitting the error information to the MMC 30 similarly to the case of the component holding and pickup process, the error can be managed by correcting the already transmitted recipe, forming a new recipe, skipping the recipe or taking another measure according to the situation in the MMC 30.

As one example of a method for detecting the presence or absence of such an error occurring in the component mounting process, it is possible to detect whether or not the component 1 has been mounted by detecting the vacuum pressure of the suction nozzle 3 with the vacuum suction turned on by the suction nozzle 3 when the suction nozzle 3 is moved up after the mounting of the

component 1. Moreover, when an error is detected as described above, it is possible to disuse the component 1 or stop the component mounting apparatus 100 according to the situation of the occurrence of the error.

(The Component Holding and Pickup Process When Component Feed Unit Is Component Feed Tray Type)

Next, as a modification example of the component mounting apparatus 100 according to the present first embodiment, control operation of the component holding and pickup process when the component feed unit 6 is not provided with the component feed cassettes 7 but served as a component feed unit that has a plurality of component feed trays will be described next.

A plurality of electronic components are arranged while being allowed to be picked up on the upper surface of the component feed tray as described above. Moreover, a plurality of component feed trays as described above are stored in the component mounting apparatus, and a component 1 can be put into a state in which it can be picked up by the suction nozzle 3 by pulling out the selected desired component feed tray and arranging the tray on, for example, the machine table 10 in the component mounting apparatus 100. The components 1 to be thus fed by the component feed tray mainly include, for example, IC components, connector components of specific shapes and so on. Moreover, the

case where the component 1 is held and picked up from the component feed tray as described above has the feature that a plurality of components 1 are not concurrently picked up by a plurality of suction nozzles 3 and the holding and pickup operation of each component 1 is sequentially performed every suction nozzle 3. Therefore, the control operation in holding and picking up the components 1 from the component feed tray becomes more simplified than the control operation in holding and picking up the components 1 from the component feed cassettes 7. A schematic explanatory flow chart schematically showing the information communications, i.e., the transfer state of recipes and events between the MMC 30, the head distribution unit 40 and the component feed distribution unit 50 (denoted by the same reference numerals as in the case where the component feed cassettes 7 are provided) in executing the component holding and pickup process is shown in Fig. 14, and reference is made on the basis of this Fig. 14. In Fig. 14, it is assumed that the component feed unit is provided with, for example, three component feed trays 201 through 203 (note that 202 is not shown) as a plurality of component feed trays, and the component feed trays are indicated by the tray number "Z = 201".

As shown in Fig. 14, a plurality of recipes R21 through R23 to be executed in the head distribution unit 40

and the component feed distribution unit 50 are formed first in the MMC 30, and the formed recipes R21 through R23 are subsequently transmitted from the MMC 30 to the distribution units 40 and 50.

Referring to a concrete example for explanation, as shown in Fig. 14, for example, in the case where the components 1 are each sucked and held by executing the component holding and pickup process of the components 1 three times for each of the suction nozzles provided for the head unit 4 (i.e., by executing the component holding and pickup process three times for each of the suction nozzles 3 with regard to the three suction nozzles 3) and thereafter the component mounting process is executed by the head unit 4, a recipe is formed every component holding and pickup process, i.e., the three recipes R21, R22 and R23 are formed in the MMC 30.

The recipe R21 transmitted to the component feed distribution unit 50 is formed containing the information of the tray number like, for example, "Z = 201" so that the component feed tray from which the component 1 is to be picked up during the component holding and pickup process executed at the first time can be recognized by the component feed distribution unit 50. Likewise, the recipe R22 and the recipe R23 are formed containing the information of the numbers of the trays from which the

components 1 are to be picked up in the next component holding and pickup process like "Z = 201" and "Z = 203", respectively.

On the other hand, the recipe R21 transmitted to the head distribution unit 40 is formed containing the information of the nozzle number like, for example, "N = 1" so that the suction nozzle 3 that should suck and hold the component 1 during the component holding and pickup process executed at the first time can be recognized by the head distribution unit 40. Likewise, the recipe R22 and the recipe R23 are formed containing the information of "N = 4" and "N = 6", respectively. Moreover, the recipes R21 through R23 transmitted to the head distribution unit 40 also contain the information of the tray numbers in addition to the information of the nozzle numbers.

Moreover, with regard to the sequence of transmitting the recipes from the MMC 30 to the head distribution unit 40 and the component feed distribution unit 50, priority may be given to either of them. However, considering the component mounting operation, it is preferable to first execute the transmission to the component feed distribution unit 50 similarly to the case of the component holding and pickup process in the component feed cassette 7.

Subsequently, as shown in Fig. 14, the execution

of the recipe R21 to be executed first out of the received recipes R21 through R23 is started in the distribution units 40 and 50.

Concretely, in the component feed distribution unit 50, the operation of selecting, pulling out and arranging the component feed tray of the tray number Z = 201 above the machine table 10 is executed on the basis of the recipe R21.

On the other hand, in the head distribution unit 40, the descent operation of the suction nozzle 3 of the nozzle number N = 1 is started on the basis of the recipe R21. If the suction nozzle 3 is moved down to the descent standby height position H1, then an event I21 is transmitted from the head distribution unit 40 to the component feed distribution unit 50.

In the component feed distribution unit 50 that has received this event I21, the arrangement operation of the component feed tray is continued without interruption. If the arrangement operation is completed and the component 1 is put in the state in which it can be picked up, an event I22 is transmitted to the head distribution unit 40 in order to transfer this state.

In the head distribution unit 40 that has received the event I22, the suction nozzle 3 is further moved down from the descent standby height position H1, and

the holding and pickup of the component 1 from the component feed tray is executed.

Although the subsequent operation is not shown in Fig. 14, operations based on the recipes R22 and R23 are sequentially executed to proceed the component holding and pickup process similarly to the case of the component holding and pickup process in the component feed cassette 7 (Figs. 5 and 6).

Although the main control operations thus executed in the distributed control system 101 has been described as the above, each of the control operations is merely one example, and the control operations of the distributed control system 101 should not be interpreted as limited only to these control operations.

For example, the relations between the MMC 30, the head distribution unit 40 and the X-Y robot distribution unit 60 in executing the component holding and pickup process can be roughly similarly applied to the information communications of the recipes and events and so on between the MMC 30, the head distribution unit 40 and the X-Y robot distribution unit 60 in executing the component mounting process. That is, in the component holding and pickup process, the head moving process for the component holding and pickup process is executed in the X-Y robot distribution unit 60, and the component holding and

pickup process is executed by executing the information communications of the recipes and events and so on between the MMC 30, the head distribution unit 40 and the X-Y robot distribution unit 60 while correlating them with one another.

Moreover, the present first embodiment has been described on the basis of the distributed control system 101 provided for the component mounting apparatus 100 that has the head unit 4 intended for executing the component mounting. However, in place of the head unit 4 provided, it is acceptable to provide, for example, an applicator head unit for supplying a bonding material of solder or the like to the board 2. This is because such an applicator head unit executes the operation of supplying the bonding material to the component mounting position of the component 1 on the board 2 while being moved in the X-direction and Y-direction by the X-Y robot 8, and therefore, the operation substantially becomes operation similar to the component mounting process and is able to be applied to the case where such operation process is executed.

Furthermore, it is acceptable to provide such a distribution unit for the board conveyance unit 9 of the component mounting apparatus 100 and adopt control operation by the distributed control system. This is because, for example, the feeding conveyance operation and

the discharging conveyance operation of the board 2 in the board conveyance unit 9 are correlated with the holding or the hold release operation of the board 2 by the stage 5 and also related to the component mounting operation by the head unit 4.

Although not illustrated in the component mounting apparatus 100 shown in Fig. 1, it is acceptable to provide a distribution unit for the component imaging device and apply control operation by the distributed control system. This is because, for example, the imaging of the component 1 that is sucked and held by the suction nozzle 3 in the component imaging device is closely related to the movement of the head unit 4 by the X-Y robot 8 and the elevation operation of the suction nozzle 3 in the head unit 4 and so on, and the component mounting process is executed while further correcting the suction and holding posture of the component 1 on the basis of the captured image.

The above description has been based on the case where the MMC 30 in the distributed control system 101 has the recipe forming section 33, and each recipe is formed in the recipe forming section 33 on the basis of the mounting data of externally inputted NC data and so on. However, the distributed control system 101 of the present first embodiment is not limited only to the above case. Instead

of the above case, it is acceptable to provide no recipe forming section 33 for the MMC 30, input each recipe preparatorily formed outside the component mounting apparatus 100 to the MMC 30 and transmit each recipe from the MMC 30 to each distribution unit. This is because a difference resides only in that the recipe formed in the MMC 30 or the externally formed recipe is transmitted and substantially similar control can be executed.

Furthermore, each recipe formed in the recipe forming section 33 of the MMC 30 is not required to be formed every time. For example, when similar control operation is repetitively executed, it is acceptable to store and retain the once formed recipe in the main memory 34 and reuse the same by reading it at need. This is because the reuse is labor saving in forming a new recipe and more efficient control operation can be executed for the similar control operation to be repetitively executed.

Although the above description has been based on the case where the distributed control system 101 is provided with the plurality of distribution units, the present invention is not limited only to the case. For example, the distributed control system may be provided with only one distribution unit. In concrete, the distributed control system 101 of Fig. 3 is provided with only the head distribution unit 40 as a distribution unit

and is provided with neither the component feed distribution unit 50 nor the X-Y robot distribution unit 60. In the above case, the motion control of the component feed unit 6 and the motion control of the X-Y robot 8 are directly executed by the MMC 30.

Referring to one example of the contents of the control operation for explanation, for example, the component feed unit 6 is provided with a component feed cassette that has a mechanism merely required to complete the component feed process before the start of the descent operation of the suction nozzle 3, the MMC 30 transmits a recipe to the head distribution unit 40 after previously completing the operation of the component feed process of the component feed cassette, and the head distribution unit 40 can complete a series of component pickup process of the descent, suction and holding and ascent of the suction nozzle 3 on the basis of the received recipe.

The above description has been based on the case where the mutually correlated control is executed by transferring the events between the distribution units in the distributed control system 101. However, it is acceptable to transfer no event between the distribution units when the mutual correlation during control is not so important instead of the above case. In such a case, the distributed control is to be individually executed in each

distribution unit on the basis of each recipe transmitted from the MMC 30.

The above description has been based on the case where the head distribution unit 40 is provided for the head unit 4, the component feed distribution unit 50 is provided for the component feed unit 6, and the X-Y robot distribution unit 60 is provided for the X-Y robot 8 in the distributed control system 101. However, the installation locations of the distribution units are not limited to the above locations, and the installation locations can be freely determined so long as the aforementioned distributed control can be executed. That is, the installation locations of the distribution units are not limited only to the objective hardware to be controlled.

(Effects of the First Embodiment)

According to the aforementioned the first embodiment, the following various effects can be obtained.

First of all, instead of adopting the "centralized control system" that intensively controls the operation of the plurality of constituent sections by one control unit as in the control system of the conventional component mounting apparatus, the constituent sections themselves are individually provided with the control units called the distributed control units. By enabling the motion control of the distribution units by making the

distributed units dialog (i.e., communicate) one another while correlating the operations of them with one another, it is possible to confirm the fundamental operation, operational controllability and so on of the individual constituent sections at an early stage in the apparatus development process and efficiently perform the confirmation of the control performance of the entire component mounting apparatus.

Concretely, in the distributed control system 101 provided with the MMC 30 that forms the recipes of the operation program to be executed in each distribution unit and transmits the recipes, the head distribution unit 40 that executes the control of the operation in the head unit 4 on the basis of the recipe, the component feed distribution unit 50 that executes the control of the operation in the component feed unit 6 on the basis of the recipe and the X-Y robot distribution unit 60 that executes the control of the operation in the X-Y robot 8 on the basis of the recipe, by transmitting the timing signal called the event from the distribution units 40, 50 and 60 to the other distribution unit 40, 50 or 60 on the basis of the states of motion control based on the recipe without the intervention of the MMC 30, the correlated motion control can be executed through mutual recognition of the states of motion control in the distribution units.

Therefore, the functions, the control software and so on to be provided for the MMC 30 can be reduced, and the functions, the control software and so on conventionally borne by the MMC 30 can be distributionally provided for the distribution units 40, 50 and 60 in place of them. Therefore, if the recipes and the events, which can be pseudo-formable even without actual constituent sections, are prepared in the apparatus development stage, the functions and the control performances can be confirmed at an early stage in distribution units, and the development period can be remarkably shortened in comparison with the conventional centralized control system.

Moreover, by shortening the development period as described above, it becomes possible to provide an apparatus that answers the various needs of the users of the component mounting apparatus in a short time taking advantage of the shortened period. Moreover, it is possible to obtain a period for sufficiently proving the controllability and therefore provide a component mounting apparatus whose control accuracy is improved.

Moreover, by making the distribution units 40, 50 and 60 distributionally bear the advanced complicated control required for the current component mounting apparatus without concentrating the control processing on one portion, the processing speed can be improved, and the

controllability can be made satisfactory.

Furthermore, the mutual correlation between the control operations of the head unit 4, the component feed unit 6 and the X-Y robot 8 can be achieved by directly transmitting and receiving the events between the distribution units by the communication control section 35 without the intervention of the MMC 30, and the control response can therefore be made satisfactory.

Moreover, the communications between the distribution units can be suppressed principally to the mere transmission and reception of the events, and each motion control is executed in each of the distribution units on the basis of the recipe. Therefore, the wirings between the distribution units can be reduced, and the apparatus manufacturing cost can also be reduced in terms of hardware.

Moreover, with particular regard to the control during the component mounting, like the mutual operation timing relations between the component holding preparation operation and the component holding main operation in the head unit 4 and the component feed preparation operation and the component feed main operation in the component feed unit 6 and the mutual operation timing relations between the component mounting preparation operation and the component mounting main operation in the head unit 4 and

the time of arrival to the timing zone during the head moving process and the time of arrival to the component mounting position in the X-Y robot 8, there is required closely correlated control between the predetermined operations and processes and the operations and processes in the other constituent sections. This therefore implies the existence of an advantage that the control operation by the distributed control system 101 to correlate the operations by transmitting the events while executing the control of operations and so forth on the basis of the recipes can be more effectively applied to the component mounting.

(Second Embodiment)

The present invention is not limited to the aforementioned embodiment and is able to be materialized in other various embodiments. For example, Fig. 15 shows a control block diagram showing the principal construction of a distributed control system 301 provided for a component mounting apparatus according to the second embodiment of the present invention.

As shown in Fig. 15, the distributed control system 301 has a construction differing from the distributed control system 101 of the first embodiment in that the X-Y robot distribution unit 60 is not provided although it is provided with an MMC 330 that is one example

of the main control section, a head distribution unit 40 that is one example of the head unit control section, a component feed distribution unit 50 that is one example of the component feed unit control section and a communication control section 35 that is an interface board for controlling information communications between the MMC 330 and the distribution units 40 and 50 similarly to the distributed control system 101. The sections that have the same constructions as those of the distributed control system 101 are denoted by the same reference numerals in the distributed control system 301. Only the sections of the different constructions will be described below.

As shown in Fig. 15, in the distributed control system 301, the MMC 330 totally includes the functions and constructions of the MMC 30 and the X-Y robot distribution unit 60 of the distributed control system 101. In concrete, as shown in Fig. 15, the MMC 330 further includes an X-Y robot driver 335 and a sensor section 336 that have functions and constructions similar to those of the X-Y robot driver 65 and the sensor section 64 in addition to a main CPU 331, an input/output section 332, a recipe forming section 333 and a main memory 334 that have functions and constructions similar to those of the main CPU 31, the input/output section 32, the recipe forming section 33 and the main memory 34. The main CPU 331 is able to control

the X-Y robot driver 335 and the sensor section 336.

In the distributed control system 301 of the aforementioned construction, there can be provided a system intermediate between the centralized control system and the distributed control system, in which the motion control of the head unit 4 and the component feed unit 8 are executed by the distribution units 40 and 50 while the motion control of the X-Y robot 8 that is required to execute the intermittent head moving process is executed in the MMC 330 in both the component holding and pickup process and the component mounting process. Accordingly, there can be provided a component mounting apparatus, which is able to obtain the effects of the first embodiment even with the distributed control system 301 that has the aforementioned construction and obtain the effects of shortening the development period and improving the controllability.

(Third Embodiment)

Further, Fig. 16 shows a schematic perspective view showing the schematic construction of a component mounting apparatus 400 that is one example of the component mounting apparatus according to the third embodiment of the present invention.

As shown in Fig. 16, the component mounting apparatus 400 differs from the component mounting apparatus 100 of the first embodiment in that two head units and two

X-Y robots are provided, and only the different sections will be described below. In Fig. 16, the sections that have the same constructions as those of the component mounting apparatus 100 are denoted by the same reference numerals.

As shown in Fig. 16, the component mounting apparatus 400 is provided with a component feed unit 6 that feeds a plurality of components 1 while allowing the components 1 to be picked up and a stage 405 that is one example of the board holding section that releasably holds two boards 2a and 2b on which the fed components 1 are mounted. The component mounting apparatus 400 is further provided with a first head unit 404a and a second head unit 404b, which are two head units that hold and pick up the components 1 fed from the component feed unit 6 and mount the components 1 on the respective boards 2a and 2b held by the stage 405 and a first X-Y robot 408a and a second X-Y robot 408b, which are two X-Y robots of one example of the head moving unit for moving the first head unit 404a and the second head unit 404b in the X-direction and Y-direction. Moreover, the first head unit 404a and the second head unit 404b are each provided with a plurality of suction nozzles 403 of one example of the component holding member for releasably sucking and holding the component 1.

With the aforementioned construction possessed by

the component mounting apparatus 400, it is possible to suck and hold and pick up the component 1 from the component feed unit 6 and execute the mounting operation of the component 1 onto the board 2a held on the right-hand side of the stage 405 in Fig. 16 by executing the operations of the first head unit 404a and the first X-Y robot 408a, and it is possible to suck and hold and pick up the component 1 from the component feed unit 6 and execute the mounting operation of the component 1 onto the board 2b held on the left-hand side of the stage 405 in Fig. 16 by executing the operations of the second head unit 404b and the second X-Y robot 408b. Therefore, the component mounting can be more efficiently executed in the component mounting apparatus 400.

Next, Fig. 17 shows a control block diagram showing the principal construction of a distributed control system 401 provided for the aforementioned component mounting apparatus 400.

As shown in Fig. 17, the distributed control system 401 is provided with an MMC 430 that is one example of the main control section, a first head distribution unit 440 that is one example of the head unit control section and executes the motion control of the first head unit 404a, a first X-Y robot distribution unit 450 that is one example of the moving unit control section and executes the motion

control of the first X-Y robot 408a, a second head distribution unit 460 that is one example of the head unit control section and executes the motion control of the second head unit 404b, a second X-Y robot distribution unit 470 that is one example of the moving unit control section and executes the motion control of the second X-Y robot 408b and a component feed distribution unit 480 that is one example of the component feed unit control section and executes the motion control of the component feed unit 6. Moreover, the MMC 430 has a function and a construction similar to those of the MMC 30 of the first embodiment, and the distribution units have functions and constructions similar to those of the distribution units of the first embodiment. Therefore, the recipes are formed in the MMC 430 and transmitted to the distribution units, and the events are transmitted and received between the distribution units. The above information communications are executed under the control of a communication control section 435.

According to the third embodiment as described above, even if the number of the objective constituent sections to be controlled is increased as in the case where the component mounting apparatus 400 is provided with the first head unit 404a and the second head unit 404b as well as the first X-Y robot 408a and the second X-Y robot 408b,

the amount of load of the control processing imposed on the constituent sections can be made roughly equivalent compared to the first embodiment by adopting the distributed control system 401. Therefore, the construction can cope with more complicated and advanced control, and efficient component mounting can be provided allowing the effects similar to those of the first embodiment to be obtained.

By properly combining the arbitrary embodiments of the aforementioned various embodiments, the effects possessed by the embodiments can be produced.

Although the present invention has been fully described in connection with the preferred embodiments thereof with reference to the accompanying drawings, it is to be noted that various changes and modifications are apparent to those skilled in the art. Such changes and modifications are to be understood as included within the scope of the present invention as defined by the appended claims unless they depart therefrom.